Serial Number 111

OPERATING AND SERVICE MANUAL

MODEL 111

VOLTAGE DIVIDER

First Edition (4/1/68)

WESTON-LEXINGTON
Weston Instruments Division
17 Hartwell Avenue
Lexington, Massachusetts 02173

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W A R R A N T Y

Weston-Lexington warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this Warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose, and to replace any defective parts thereof. This Warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed to the customer. In this case, an estimate will be submitted before the work is started.

IN ANY FAULT DEVELOPS, THE FOLLOWING STEPS SHOULD BE TAKEN:

1. Notify us giving full details of the difficulty; include the Model number and serial number. On receipt of this information, we will give you service data or shipping instructions.
2. On receipt of shipping instructions, forward the instrument prepaid to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SECTION 1

DESCRIPTION AND SPECIFICATIONS

1.1. GENERAL DESCRIPTION

The Model 111 plug-in is a high-resolution voltage divider providing good accuracy and exceptional frequency response when used with the Weston 100 series Precision Oscillators at a constant 200Ω output impedance over the frequency range from 10Hz to 100kHz. The plug-in consists of a three-decade plus vernier wide-band voltage divider which divides the output of the oscillator from 0 to 12 volts over four multiplier ranges. Complete specifications are given in Section 1.3. The decade divider has settings from 0.00 to 12.10 (11.XX) with a continuously variable vernier covering 0.000 to 0.00X. The four multiplier ranges are X1, X0.1, X0.01 and X0.001. Resolution of better than one microvolt is available on the X0.001 multiplier range with the vernier covering the range from 0 to 10 microvolts. A floating output connector is included which isolates the divider circuit ground from the chassis ground and allows for floating operation when the oscillator switch is in the floating position. (See 100 series oscillator manual for floating operation.)

1.2. USES

Flat frequency-response, constant output-impedance, high resolution, and accuracy make the combination of the Model 111 plug-in and Weston Precision Oscillator useful in such applications as frequency-response testing from 1mV to 12 volts, distortion analysis, and measuring the gain of an amplifier or system. With the fixed high-level reference output available from the basic oscillator and Model 111 plug-in providing low-level

signals, suppressed-carrier systems which utilize phase-sensitive demodulators can be easily evaluated. With a quadrature reference also available from the oscillator, quadrature rejection of phase-sensitive systems can also be analyzed.

1.3. SPECIFICATIONS

Number of Phases:	1 (ØA)
Controls:	4 decade divider with a X1, X0.1, X0.01 and X0.001 range multiplier which provides 1 microvolt per division in the X0.001 multiplier position. 4th decade is a potentiometer.
Output Voltage Settings:	0 to 12.11 volts (X1 range) 0 to 1.211 volts (X0.1 range) 0 to 0.1211 volts (X0.01 range) 0 to 0.01211 volts (X0.001 range)

Total Frequency Response Including Oscillator				
Range Position	10Hz-20Hz	20Hz-20kHz	20kHz-50kHz	50kHz-100kHz
X1‡	0.02% ±0.1mV	0.01% ±0.15mV	0.02% ±0.2mV	0.05% ±0.3mV
X0.1‡	0.02% ±20μV	0.01% ±20μV	0.05% ±30μV	0.07% ±50μV
X0.01‡	0.02% ±2μV	0.02% ±2μV	0.07% ±10μV	0.1% ±20μV
X0.001	0.02% ±1μV	0.05% ±1μV	0.1% ±3μV	0.15% ±5μV

Accuracy at 1kHz‡	±0.25% X1 range ±0.35% X0.1 range ±0.45% X0.01 range ±0.55% X0.001 range

‡With first digit not set to zero

Amplitude Stability Vs. Temperature‡ (total including oscillator):	±0.03%/°C
Output Impedance:	200Ω ±0.2%
Available Output Current:	Matched 200Ω load; 30mA max. *Short circuit load; 60mA max.
Maximum Input Current to Plug-in:*	No load on plug-in; 23mA in X1, 27mA in X0.1, X0.01 and X0.001. Matched 200Ω load; 47mA. Plug-in "short circuit" load, 9V setting and below; 55mA. *Plug-in "short circuit" load; above 9V setting; 78mA.
Output:	Front panel BNC connector.
Temperature Range for Specified Performance:	15° - 40°C
Operating Temperature Range:	0° - 52°C
Shock and Vibration:	Designed to meet all performance specifications after being subjected to the applicable shock and vibration requirements of MIL-T-945.
Dimensions and Weight:	4-1/8" h x 5-3/16" w x 5-9/16" d behind front panel (excluding connector); 2-1/2 lbs.

*Current available from oscillator front panel fixed output in mA equals 60 less plug-in input current. If the input current to the plug-in exceeds 60mA, distortion and frequency response will be slightly degraded due to overloading the oscillator.

SECTION 2

INSTALLATION AND OPERATION

2.1. INSTALLATION

The plug-in module has been designed to fit into the front panel receptacle on the Precision Oscillator (see Precision Oscillator manual). Before inserting plug-in into the receptacle, place plug-in locking latch (see Figure 2-1) in a position such that the plug-in will slide completely into the receptacle. When fully inserted, the front panel of the plug-in should be flush with the oscillator front panel. Turn locking latch in the clockwise direction to lock the plug-in firmly in place.

2.2. OPERATING CONSIDERATIONS

2.2.1. OUTPUT IMPEDANCE

For full accuracy and ease of application, the load impedance should be as high as possible (greater than 400KΩ). The divider itself is calibrated for no load, with a matched 200Ω load, the output voltage will be half the indicated value. For any load (R_L), the output voltage equals:

$$\text{Divider output} = \frac{R_L}{R_L \text{ X } 200} \text{ X dial setting}$$

where R_L is in ohms.

2.2.2. PLUG-IN CURRENT DRAIN WITH LOAD

The output amplifiers in the oscillator are rated at 60mA maximum for full specification. Because their outputs are brought directly to the front panel of the oscillator at a low impedance level, it is possible to draw more than 60mA. Although

this does not harm the amplifiers in any way, the oscillator specifications are no longer maintained. When a divider plug-in is being driven by the amplifiers, the total current available at the low impedance front-panel outputs is reduced by the amount used by the plug-in. The currents for different loads on the divider must be subtracted from the specified 60mA level to determine how much current is still available from the zero impedance output. For the Model 111 plug-in, only phase A is used, allowing phase B low-impedance oscillator front-panel output to supply 60mA regardless of the load on the divider output. (See specifications, Section 1.3., for input current for different loads.)

2.2.3. CAPACITIVE LOADING

A capacitive load on the divider will effect the frequency response of the output voltage from the divider. With capacitive loading, the following formula should be used to calculate additional frequency-response error:

$$\text{Additional \% error} \approx 0.78 f^2 \left[C_{\text{external}} + 50 \right] \times 10^{-10}$$

where C is in pf
f is in kHz

2.3. OPERATING PROCEDURE

a. Insert plug-in into oscillator receptacle on front panel (see Section 2.1.).

NOTE: The oscillator need not be turned off when plug-ins are inserted or removed.

b. Set dials and multiplier switch to the desired voltage (see Section 2.2.1. for heavy loads).

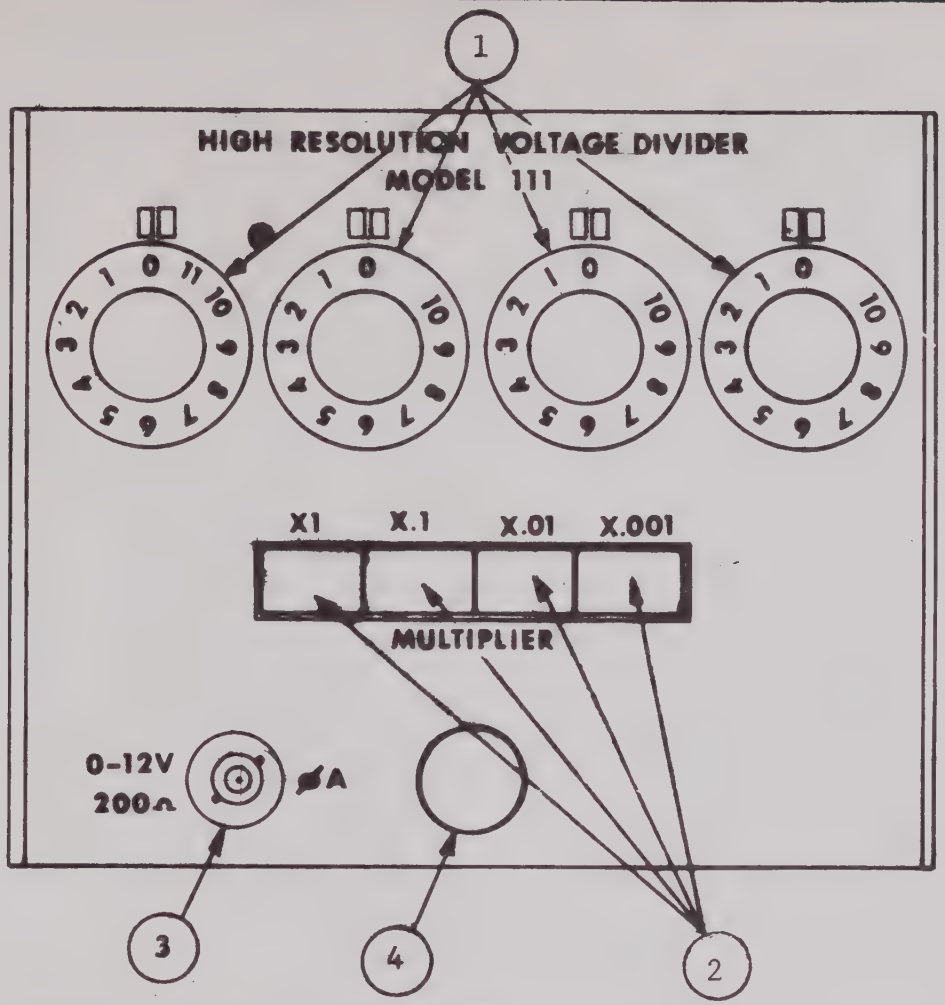
c. Attach load to the output connector on the front of the plug-in.

2.4. IMPEDANCE ADAPTORS

Some loads are affected by an impedance mismatch, or frequency response may be degraded due to large capacitive loads. For such cases, impedance adaptors may be necessary. The following is a list of adaptors and their part numbers which are available as accessories:

200Ω to 600Ω adaptor - Weston Part No. 02-117-308

200Ω to 50Ω X10 attenuator - Weston Part No. 02-117-207



1. DIVIDER SWITCHES AND VERNIER (SW10, 11, 12 and R134) divides Precision Oscillator phase A output from 12.10 volt to 1μV when used in conjunction with the multiplier ranges.

2. MULTIPLIER RANGES (SW13, 14, 15 and 16) provide multiplication of divider switches by X1, X0.1, X0.01 and X0.001.

3. OUTPUT (J111) attenuated phase A output of Precision Oscillator.

4. PLUG-IN LOCKING LATCH, turn fully counter-clockwise to insert or remove plug-in, fully clockwise to lock plug-in into oscillator.

Figure 2-1. Front Panel Controls and Connectors

SECTION 3

THEORY OF OPERATION

The Model 111 plug-in is shown in simplified form in Figure 3-1, below.

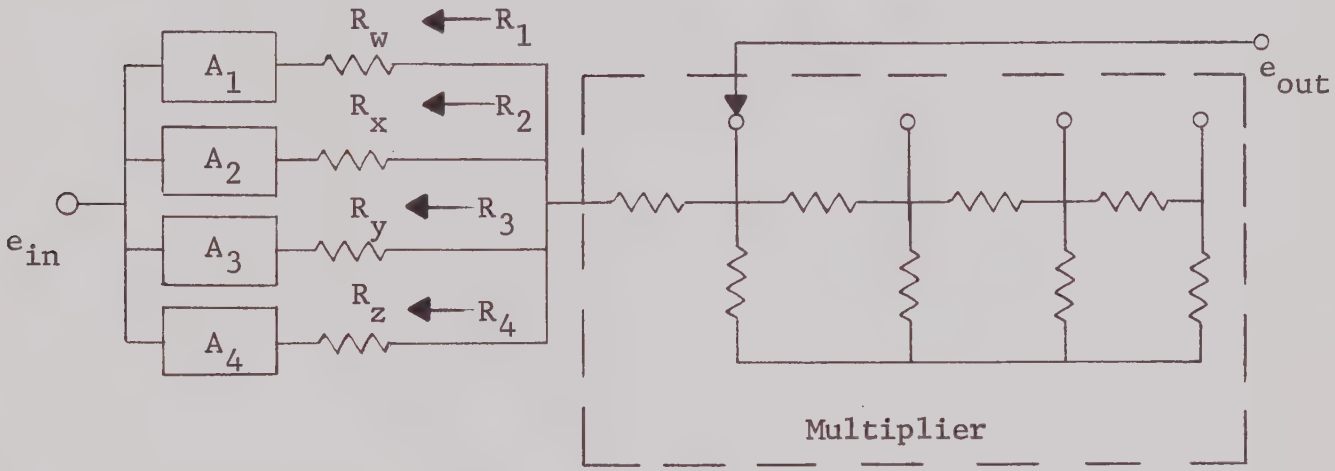


Figure 3-1
Simplified Schematic

Most precision dividers (Kelvin-Varley, etc.) yield fine ratio accuracies, but output impedance varies with setting. This change in loading is not desirable as it seriously affects voltage accuracy under load.

In Figure 3-1, A_1 represents a switched potentiometer. Different resistors are selected for each switch position such that R_1 is held constant with switch setting (see Schematic 04-117-511-1). A_2 and A_3 are similar to A_1 except that R_x and R_y must also act as weighting resistors such that the full-scale effect of A_2 is 1/12 A_1 and the full-scale effect of A_3 is 1/10 A_2. A_4 is a true potentiometer whose weighting resistor R_z is large

enough to make R_4 essentially constant with potentiometer setting. With this weighting resistor, the full-scale effect of A_4 is 1/1200 of A_1.

The total effect of A_1, A_2, A_3 and A_4 plus their associated resistors is a linear continuously-adjustable divider with constant (±0.25%) output impedance. The multiplier is a simple ladder attenuator with a high degree of shielding between input and output to maintain the frequency response of the divider to low voltage setting. There is, however, still some feedthrough capacitance from input to output at low divider settings and at high frequencies which has been drastically reduced by additional compensation circuitry. Figure 3-2 shows in block diagram form the technique used to reduce this effect. In Figure 3-2, an equal but opposite amount of the signal current is generated by a source which is exactly 180° out of phase with the divider input source. The net result is a drastic reduction in the error caused by the feedthrough capacitance.

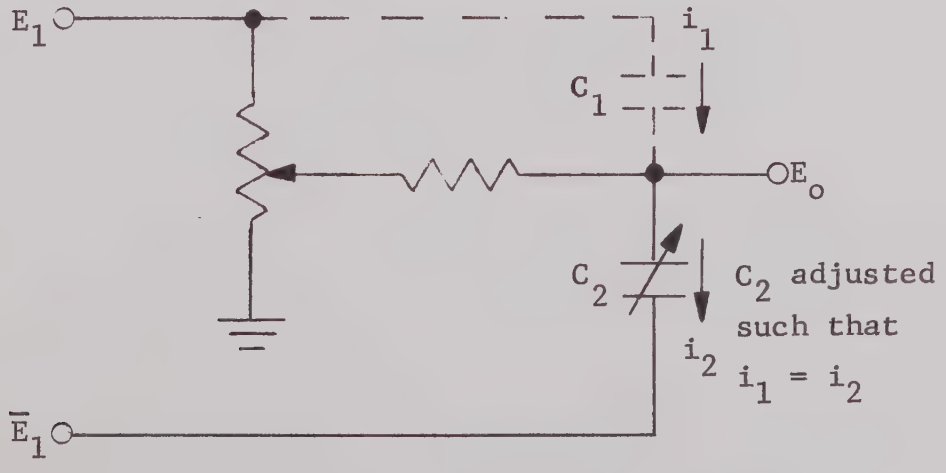


Figure 3-2

Feedthrough Compensation

SECTION 4

CALIBRATION

4.1. DC PERFORMANCE TEST AND CALIBRATION

The dc performance test setup is illustrated in Figure 4-1. A DC power supply (EDC Model VS-111, or equivalent) and a digital voltmeter (Weston Model 1423, or equivalent) are required for this test. The purpose of this test is to check, and if necessary, calibrate the divider. To perform the test, proceed as follows:

a. Make test setup illustrated in Figure 4-1.
b. Set decade dials and vernier to read 1.000.
c. Set multiplier switch to X1.
d. Apply 12.11 volts to plug-in as shown in Figure 4-1.
e. The output of the divider is now read on the digital voltmeter and should be 1V ±2.5mV. If the output is not within this limit, adjust R13 until the output is within specifications.
f. Set dials to read 2.000.
g. Keep multiplier at X1 position.
h. Read output on digital voltmeter. Output should be 2V ±5mV. Adjust R11 until output is within specifications.
i. Because of interaction between trims, repeat steps b. through h. until all requirements are satisfied.
j. Set dials to read 10.00 and multiplier to X0.1.
k. Read output on digital voltmeter. Output should be 1V ±3.5mV. Adjust R87 until output is within specifications.

l. With dials set to 10.00, set multiplier to X0.01.

m. Read output on digital voltmeter. Output should be 0.1V ±450μV. Adjust R92 until output is within specifications.

n. With dials set to 10.00, set multiplier to X0.001.

o. Read output on digital voltmeter. Output should be 0.01V ±55μV. Adjust R97 until output is within specifications.

p. With multiplier switch set to X1, switch first decade through each position and observe output on digital voltmeter. The output should be within ±0.25% of dial indication.

q. A check on every decade is not necessary. A quick check can be made with the dials set to 1.111 and 1.555 volts and the multiplier switch set to X1. The output should be within ±0.25% of dial reading.

4.2. AC PERFORMANCE AND CALIBRATION PROCEDURE

The ac performance and calibration test consists of two parts: a) feedthrough reduction trim, and b) frequency response. Part a should be performed before part b, as feedthrough will affect the divider frequency response.

4.2.1. FEEDTHROUGH REDUCTION TRIM

a. Insert plug-in oscillator as outlined in Section 2.1.

b. Remove oscillator top cover (see oscillator manual for instructions).

c. Turn oscillator on and set frequency to 100kHz.

d. Set plug-in dials and vernier to zero and multiplier switch to X1.

e. Measure output on VTVM (H-P Model 400D, or equivalent).

f. If output is greater than 300μV, adjust capacitor C2 in plug-in until output is less than 300μV.

4.2.2. FREQUENCY RESPONSE TESTING

The frequency response of the divider is controlled by two factors: 1. The geometry of the divider, and 2. The capacitance and/or inductance in the resistors. Very complicated techniques have been developed to measure divider frequency response at low level settings which would be very difficult to perform in most calibration laboratories. For this reason a two-point frequency-response test at high level outputs will generally be sufficient to guarantee that geometry and resistors have not changed. Figure 4-2 shows a typical test setup. To perform the test, proceed as follows:

a. Insert plug-in into oscillator.

b. Turn oscillator on and set to 400Hz; set plug-in dials to read 6.000 and multiplier to X1.

c. Connect 5 volt high-frequency thermal converter (HFTC Engelhard Industries Part No. 34970-10C, or equivalent) to the divider output.

NOTE: Because we are only interested in frequency response, the decrease in output voltage due to loading by the converter is inconsequential.

d. Using the HFTC as a transfer device, measure the plug-in output.

e. Set the oscillator frequency to 100kHz and repeat step d. This reading should not exceed ±0.05% of the reading of step d.

f. Set plug-in dials to read 1.000 and multiplier to X1.

g. Using a 1 volt HFTC, repeat steps c., d., and e. The difference between the 400Hz reading and 100kHz reading should not exceed ±0.08%.

h. Step g. may be repeated on the X0.1 multiplier position by setting the divider dials to read 10.000 and the multiplier to X0.1. The 1 volt HFTC would still be used for this test. The difference between the 400Hz, and 100kHz reading should not exceed ±0.075%.

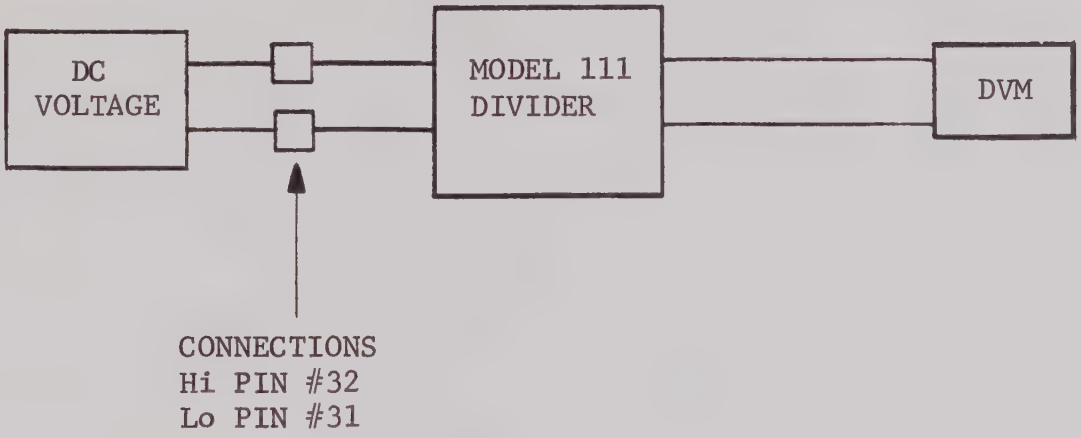


Figure 4-1. DC Performance Calibration Setup

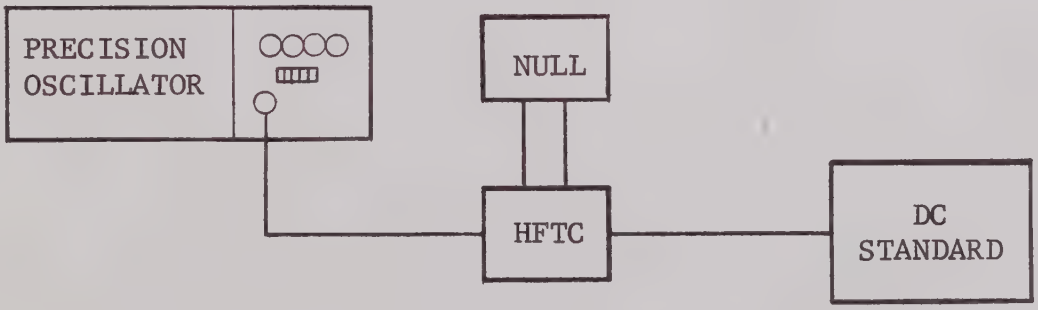


Figure 4-2. Frequency Response Setup

SECTION 5

CIRCUIT AND LOCATION DIAGRAMS

This section contains the overall schematic and location diagrams for the Model 111 Voltage Divider. The schematic is an overall schematic of the plug-in, and when used in conjunction with the Theory of Operation (Section 3.), should aid in understanding full operation of the plug-in.

Following is a list of the diagrams included in this section:

Number	Title
04-117-511-1	Schematic, 111 Plug-In
04-117-511-2	Location, 111 Plug-In

SECTION 6

REPLACEABLE PARTS

This section contains ordering information for replacement parts listed by assembly and model. Where manufacturer and type are not given (designated by **), parts may be ordered directly from Weston-Lexington. These parts should be identified by Weston-Lexington part number; the instrument model number and serial number should also be specified.

Following is a list of assemblies included in this section:

Name	Page
Main Assembly	6-2
Switch Board 1	6-3
Switch Board 2	6-4
Voltage Divider Board 5	6-5
Voltage Divider Board 6	6-6
Voltage Divider Board 7	6-7

MAIN ASSEMBLY 04-117-511

REFERENCE DESIGNATION	DESCRIPTION	W-L PART NO	MANUFACTURER	MFR. TYPE
	Panel, Front	08-117-161	Weston	--
	Knob, Extractor	03-117-200	Weston	--
	Latch, Panel	07-117-306	**	--
	Insulator, Connector BNC	08-117-366	Weston	--
	Plate, Rear	03-117-367	Weston	--
	Knob, Front Panel	08-117-372-1	**	
	Knob, Front Panel	08-117-372-5	**	
P6	Connector, Male, 32 Pin	29-033-232	Amphenol	26-4100-32P
J111	Connector, BNC Receptacle	29-057-001	Amphenol	31-105
SW10	Switch, Detent & Shaft	34-063-999-9	**	--
SW12	Switch, Detent & Shaft	34-063-999-10	**	--
SW11	Switch, Detent & Shaft	34-063-999-11	**	--
R134	Resistor, Variable, 10K	40-419-001	Allen-Bradley	Type J

SWITCH BOARD 1 04-117-511

REFERENCE DESIGNATION	DESCRIPTION	W-L PART NO	MANUFACTURER	MFR. TYPE
SW13,14,15,16	Switch, Pushbutton, 6 Pole, 12 Pos.	34-074-001	**	--
R87,92,97	Resistor, Variable, 2K	40-421-001	Mallory	MTC23L4

SWITCH BOARD 2 04-117-511

REFERENCE DESIGNATION	DESCRIPTION	W-L PART NO	MANUFACTURER	MFR. TYPE
R86,91,96	Resistor, Film, 7.68K, 1W, 1%	40-002-076	IRC	CEC
R98	Resistor, Film, 226.05Ω, 1W, 0.1%	40-016-142	IRC	CEC
R93	Resistor, Film, 251.94Ω, 1W, 0.1%	40-016-143	IRC	CEC
R88	Resistor, Film, 254.66Ω, 1W, 0.1%	40-016-144	IRC	CEC
R85	Resistor, Film, 1800.1Ω, 1W, 0.1%	40-016-158	IRC	CEC
R90,95	Resistor, Film, 1981.4Ω, 1W, 0.1%	40-016-160	IRC	CEC

VOLTAGE DIVIDER BOARD 5 04-117-511

REFERENCE DESIGNATION	DESCRIPTION	W-L PART NO	MANUFACTURER	MFR. TYPE
SW11	Switch, Wafer, 1 Pole, 11 Pos. Shtg.	34-063-207	CTS	212
R85	Resistor, Film, 243K, 1W, 1%	40-002-112	IRC	CEC
R135	Resistor, Film, 1K, .25W, 10%	40-012-001	Allen-Bradley	CB
R43,44	Resistor, Film, 80.6Ω, 1W, 0.1%	40-016-024	IRC	CEC
R25,26,27,28,29,30, 31,32,33,34	Resistor, Film, 806Ω, 1W, 0.1%	40-016-048	IRC	CEC
R35,51	Resistor, Film, 2015Ω, 1W, 0.1%	40-016-054	IRC	CEC
R37,49	Resistor, Film, 1289.6Ω, 1W, 0.1%	40-016-058	IRC	CEC
R41,45	Resistor, Film, 322.3Ω, 1W, 0.1%	40-016-145	IRC	CEC
R101	Resistor, Film, 403Ω, 1W, 0.1%	40-016-147	IRC	CEC
R39,47	Resistor, Film, 725.5Ω, 1W, 0.1%	40-016-153	IRC	CEC
C1	Capacitor, Mica, 20pf, 300V	45-001-003	Electro-Motive	DM15C
C3	Capacitor, Mica, 22pf, 300V	45-002-002	Electro-Motive	DM15E
C2	Capacitor, Variable, 2-8pf	45-504-002	Erie	538

VOLTAGE DIVIDER BOARD 6 04-117-511

REFERENCE DESIGNATION	DESCRIPTION	W-L PART NO	MANUFACTURER	MFR. TYPE
SW10	Switch, Wafer, 1 Pole, 11 Pos., Shtg.	34-063-007	CTS	212
SW12	Switch, Wafer, 1 Pole, 11 Pos., Shtg.	34-063-207	CTS	212
R103	Resistor, Film, 22162Ω, 1W, 0.1%	40-016-163	IRC	CEC
R99	Resistor, WW, .36Ω, .25W, .01%	40-147-003	Daven	1274

VOLTAGE DIVIDER BOARD 7 04-117-511

REFERENCE DESIGNATION	DESCRIPTION	W-L PART NO	MANUFACTURER	MFR. TYPE
R30,55	Resistor, Film, 14.7Ω, 1W, 1%	40-002-008	IRC	CEC
R68,69	Resistor, Film, 80.6Ω, 1W, 1%	40-002-026	IRC	CEC
R67,70	Resistor, Film, 324Ω, 1W, 1%	40-002-040	IRC	CEC
R66,71	Resistor, Film, 732Ω, 1W, 1%	40-002-047	IRC	CEC
R53,54,55,56,57,58, 59,60,61,62,63	Resistor, Film, 806Ω, 1W, 1%	40-002-048	IRC	CEC
R65,72	Resistor, Film, 1.27Ω, 1W, 1%	40-002-056	IRC	CEC
R64,73	Resistor, Film, 2.05Ω, 1W, 1%	40-002-062	IRC	CEC
R10,12	Resistor, Film, 3.32Ω, 1W, 1%	40-002-067	IRC	CEC
R16,23	Resistor, Film, 146.53Ω, 1W, 0.1%	40-016-022	IRC	CEC
R1-9	Resistor, Film, 80.6Ω, 1W, 0.1%	40-016-024	IRC	CEC
R15,17	Resistor, Film, 82.5Ω, 1W, 0.1%	40-016-025	IRC	CEC
R18,22	Resistor, Film, 87.92Ω, 1W, 0.1%	40-016-026	IRC	CEC
R14,24	Resistor, Film, 219.8Ω, 1W, 0.1%	40-016-032	IRC	CEC
R19,21	Resistor, Film, 43.96Ω, 1W, 0.25%	40-017-001	IRC	CEC
R11,13	Resistor, Variable, 750Ω	40-420-001	Mallory	MTC751L1

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